Understanding Static and Dynamic Visualizations

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Abstract. Data from expert forecasters making weather reports (using the talk aloud method) were coded for dynamic comments as well as whether the visualization itself was static or dynamic. Preliminary results strongly suggest that meteorologists build dynamic mental models from static images.

Introduction

Animations and dynamic displays have been used for many different purposes in recent years. Animations have been used to teach procedures in HCI (Palmiter & Elkerton, 1993), to teach computer science algorithms (Byrne, Catrambone, & Stasko, 1999), to teach how something works (Mayer & Anderson, 1991; Pane, Corbett, & John, 1996), and for comprehension of other complex dynamic systems (Lowe, 1999).

Unfortunately, the usefulness of animations has been questioned by many researchers (Palmiter & Elkerton, 1993; Pane et al., 1996), leading some researchers to suggest using animation only in very limited situations (Betrancourt & Tversky, 2000). This finding is somewhat surprising because some domains have a very strong dynamic component to them (*e.g.* computational fluid dynamics, meteorology), and practitioners in these fields need to understand the dynamic aspects in their domain. Do practitioners in these kinds of domains use static images to understand the dynamics, even though static images can impose a high working memory as people try to animate them (Hegarty & Sims, 1994)?

We know of no studies that have examined whether people use animations as part of their job, and what kind of information is extracted from animations and static visualizations. This study will examine expert weather forecasters as they create a weather report. We will examine the type of visualization they examine (static, dynamic, or a series of static visualizations) and the type of information they extract from those visualizations (static or dynamic).

Method

Task . The task was to prepare a written brief for an airplane flown from an aircraft carrier to a destination 12 hours in the future. (The destination was Whidbey Island, Washington State.) In order to do this, the forecasters had to determine detailed qualitative and quantitative information about what the weather would be like at that time. This task took about 2 hours.

Participants, Apparatus and Procedure. All forecasters were Naval or Marine forecasters or forecasters-in-training, who had 1-16 years of forecasting experience. They worked in teams of two, with the more experienced person acting as the lead forecaster, while the other person worked as the “tech” or assistant. There were a total of 4 teams of forecasters. The data for this analysis was taken from the more experienced forecasters only, who had an average of 10 years of forecasting experience.

The apparatus consisted of two Windows-NT workstations that were situated side by side. Each forecaster and assistant worked side by side on these two computers. Information about the weather that the forecaster extracted, was coded as shown in Table 1.

Table 1. *Sample coding scheme for weather extractions.*

Category	Example
Static	They are currently clear, 10 miles visibility, no wind…
Dynamic	24 hours from now, definitely a lot of precip. moving into the area...

The data were coded for proportion of dynamic extractions made for each kind of visualization. There were three categories of visualization, as shown in Table 2.

Table 2. *Sample coding scheme for visualizations.*

Category	Example
Static	Visualization showing wind speed and direction for the 500 millibar level.
Set	A series of visualizations showing temperature and winds at different times (*i.e.* 12 hours in future, 18 hours in the future, *etc.*).
Dynamic	Animated visualization showing clouds moving in over region.

Results

Forecasters looked at a total of 85 visualizations. They extracted information from these visualizations 321 times (an average of 3.8 extractions/visualization). Forecasters had the opportunity to look at dynamic images either by choosing animation loops or by looking at sets of images shown at different times. However, they chose to look at static images most of the time: 59% of the visualizations were static images. But this reliance on static images did not prevent forecasters from making dynamic extractions about the weather for a substantial portion of the time: 36% of the extractions in this study were dynamic comments.

Table 3 shows the percentage of dynamic extractions made for each type of visualization.

Table 3. *Percentage of dynamic extractions*

Visualization	Observed	Expected numbers based on number of visualizations of each type examined

Dynamic	10	1.18
Sets	18	40
Static	72	58.82

We expected that the percentage of dynamic extractions would be greater for visualizations that had a dynamic quality to them either because they were animated images ("dynamic"), or because they formed sets of images ("sets"). However, Table 3 demonstrates that forecasters made most of their dynamic comments to static images, $\chi^2_{(2)} = 68.2$, $p < .001$, Bonferroni adjusted chi-square significant at $p < .01$. This pattern of results holds true even when the number of different types of visualizations is taken into account, $\chi^2_{(2)} = 79.5$, $p < .001$.

Discussion

The data show that when given the opportunity to choose any kind of image, forecasters chose static images most of the time. However, this did not prevent them from explicitly extracting dynamic information about the weather for a substantial proportion of the time. In addition, most of these dynamic extractions happened when the forecaster was looking at static images.

Thus the data strongly suggest that forecasters build dynamic, qualitative mental models (Trafton *et al.,* 2000) and they construct their models primarily from static images.

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